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**Application of a new system for classifying root canal morphology in undergraduate teaching and clinical practice: A national survey in Malaysia**

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**Running title:** Feedback on a new canal morphology classification

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## Introduction

Adequate knowledge and understanding of root canal configurations are essential for successful root canal treatment (Vertucci 2005). The system for defining root canal morphology proposed by Vertucci *et al.* (1974), and its supplementary categories introduced by others (Gulabivala *et al.* 2001, 2002, Ng *et al.* 2001, Sert & Bayirli 2004) have been the most commonly used classification system. However, over time, a number of deficiencies and inconsistencies have been associated with the system, such as the inability to define premolars with two/three roots and the fact that many root canal systems cannot be classified (Ahmed *et al.* 2017, Ahmed & Dummer 2018a). Recently, an alternative coding system for classifying root and canal morphology was proposed, which provides detailed information on tooth notation, number of roots and root canal configuration (Ahmed *et al.* 2017).

To deliver the information required to allow dental students to learn and acquire knowledge for clinical practice is a significant responsibility (Qualtrough 2014). Inadequate understanding and inability to systematically address normal and unusual anatomical variations of roots and root canals in a given tooth are the main causes of failure of primary root canal treatments as a consequence of persistent infection within the root canal space, that leads to inflammation of the periapical tissues and postoperative pain (Cantatore *et al.* 2006). Such treatment failures usually result in tooth extraction or require more invasive and expensive conventional root canal and/or surgical retreatment procedures with varying rates of clinical success depending on a number of aetiological and technical factors (Ng *et al.* 2008).

Survey studies are valid research tools that provide information on opinions, attitudes, and behaviours of respondents (Lydeard 1991). Surveys should be designed well in order that research questions are addressed in a proper manner thus providing an accurate assessment of a given subject. Student questionnaires enable continued assessment, evaluation and improvement of endodontic education programmes and applications (Mala *et al.* 2009, Ahmed *et al.* 2014, Davey *et al.* 2015). Several valuable surveys have been published that highlight current trends and directions in education related to endodontic teaching (Alraisi *et al.* 2019), antibiotic prescribing (Al Masan *et al.* 2018, Salvadori *et al.* 2019) and other topics (Baaij *et al.* 2019).

Recent reports have documented the application of the new system for classifying root and canal morphology in research and clinical practice (Ahmed & Dummer 2018a, Saber *et al.* 2019); however, there is no evidence to support its application when teaching undergraduate students about root canal anatomy. This survey study sought to investigate the students' feedback on two classification systems (Vertucci *et al.* 1974, Ahmed *et al.* 2017) for root canal morphology.

## **Methodology**

### *Study design*

This survey study consisted of two phases: 1) A PowerPoint (PPT) presentation describing two classification systems for root canal morphology (Vertucci 1974 and its supplemental configurations, Ahmed *et al.* 2017) was delivered to final year undergraduate dental students in eight Malaysian dental schools. 2) After the presentation, printed questionnaires were

distributed, collected and analysed. The questionnaire was designed to compare the classification systems in terms of accuracy, practicability, understanding of root canal morphology and recommendation for use in preclinical and clinical courses as well as clinical practice.

### *Study population*

The study included all final year undergraduate dental schools in eight dental schools within four different states in Malaysia (Figure 1). Ethical approval was obtained from University of Malaya number DF RD1801/0004(L). Additional ethical approvals have been obtained from two universities UiTM (REC/397/19) and IIUM (IREC 2019-115).

One lecturer from each dental school was invited to join the survey and take responsibility for inviting the students and arranging the venue and time of the presentation based on their students' schedule.

### *Preparation of the PowerPoint presentation*

The principal investigator and project team (six – five staff members from the University of Malaya, Malaysia, and one staff member from Cardiff University, UK) discussed the design of the PPT presentation and questionnaire for final year students in Malaysia. A Microsoft PPT presentation (35 slides – Supplementary material 1) was prepared with three components – 1) an introduction and references (3 slides); 2) Vertucci's classification (and its supplemental configuration types) for root canal morphology (Vertucci *et al.* 1974, Cleghorn *et al.* 2008) (11 slides); 3) a new system for classifying root and root canal morphology (Ahmed *et al.* 2017)

(11 slides) together with examples of a range of teeth interpreted using the two systems (10 slides). The description of the two classification systems had the same number of slides, font size, slide background and transition animations; however, since the new system comprises codes with superscripts, the font size of the codes to define root and canal morphology was made larger to allow better visibility. Only two colours (black and red) were used for the text and illustrations.

#### *Preparation of the questionnaire*

The paper-based questionnaire consisted of five multiple choice questions and one open-ended question (Supplementary material 2). A definition of terms was added below every question (whenever needed) to provide consistent information for the questions amongst the students as an aid to their understanding. The presentation and the questionnaire were piloted by the project team to ensure question readability, clarity, validity, and functionality and to assess the time required to complete the survey. The estimated time for the presentation was 30-40 minutes, and the questionnaire 10-20 minutes. Therefore, a slot of one hour was reserved in every school to conduct the study.

#### *Criteria for selection of the presenters*

Two presenters were chosen to deliver background talks to the undergraduate students (four schools for each presenter). The selection criteria were as follows: a) a presenter graduated from a dental school not less than 10 years, b) had at least 3 years of teaching experience, and c) did not contribute to the development of either classification system. After selection, two

calibration sessions were undertaken to ensure consistency when presenting the talks by both lecturers (ZA and NHA).

#### *Delivering the presentations and distribution of the questionnaires*

The presentations were delivered in the morning (time range from 8 AM to 9 AM or 9 AM to 10 AM) before clinical sessions in an attempt to ensure that students gave their full attention to the topic. Students were given the opportunity to decline from participating in the survey, and those that agreed were assured anonymity. The study was supported by a university grant (BK010-2018) that allowed an honorarium to be given to each student. Before the presentation, a brief introduction was given to all participants that set out the purpose of the study and the format of the questionnaire. After delivering the presentation, the printed questionnaires were distributed, and all anonymously completed questionnaires were collected.

#### *Statistical analysis*

The information and data from the completed questionnaires were entered into an electronic database (SPSS version 22, Chicago, IL, USA). Comparisons between presenters, universities and answers of all universities (combined) were analysed using the exact test followed by examining standardized adjusted residual with Bonferroni correction as post hoc test. The level of significance was set at 0.05 ( $P=0.05$ ).

### **Results**

Out of 447 undergraduate students, 382 (86%) completed the questionnaires. The Faculty of Dentistry, University of Malaya (UM) had the highest attendance rate (98%) followed by

University Sains Islam Malaysia (USIM) (94%). Figure 1 shows the percentage attendance of students in each school.

For the first presenter, the attendance rate was 89% (183 out of 210), whilst for the second presenter, it was 82% (199 out of 237). The students' responses for all questions were similar for both presenters (Figure 2) ( $P>0.05$ ), except for question number 1, in which a significant difference was detected ( $P<0.05$ ); for the first presenter, 94% of students believed the new system was more accurate compared to the Vertucci system and its supplemental configuration compared to 86% for the second presenter (Figure 2).

Overall, 90% and 96% of students reported that the new system for classifying root and canal morphology was more accurate and more practical compared to the system of Vertucci and its supplemental configurations ( $P<0.001$ ), with only 10% and 5% reporting that both had the same level of accuracy and practicability, respectively (Table 1, 2). Except for one school [School of Dentistry, International Medical University (IMU)], no significant difference was detected between the responses of students for the accuracy and practicability of both classification systems at the different schools ( $P>0.05$ ).

Overall, 97% of students believed that the new system helped their understanding of root and canal morphology more than the Vertucci classification and its supplemental configurations ( $P<0.001$ ) (Table 3). At the same time, 98% and 97% of students recommended that the new system should be included in their curriculum for preclinical and clinical courses, respectively (Tables 4, 5). Except for one school [Universiti Sains Malaysia (USM)], no significant



difference was detected for the responses of questions number 4 and 5 between the schools ( $P>0.05$ ).

In general, the students favoured the use of the new system compared to the Vertucci classification ( $P<0.001$ ) (Tables 1-5). In the comments section of the questionnaire, students added free text as listed in Table 6.

## **Discussion**

Endodontic education has evolved through the years and has been driven by advances in knowledge, materials, equipment and educational methods (Qualtrough & Dummer 1997, Alraisi *et al.* 2019). The challenge for university teachers is to produce competent general dental practitioners, which is becoming more challenging in the light of increasing student numbers, decreased numbers of qualified dental educators, limited educational budgets, increased time pressures on the curriculum and the ever-increasing range of techniques, materials and technology when treating patients (Wilson 2004, Lynch *et al.* 2007, Mala *et al.* 2009, Al Raisi *et al.* 2019, Nagendrababu *et al.* 2019). Root and canal morphology is an integral component in the Endodontic curriculum, and it is the initial educational step to develop understanding before practicing root canal treatment procedures.

Classifications play a central role in science, where they are used not only as a way to organize knowledge but also as a powerful tool for defining characteristic features of a given subject in an accurate manner (Stains & Talanquer 2008). Examining the students' ability to understand, use and apply classifications is essential. This survey study compared students' feedback on a

new system for classifying the root and canal morphology (Ahmed *et al.* 2017) with that of Vertucci *et al.* (1974) and its supplemental configurations.

This survey study was undertaken in eight Malaysian dental schools located in four different States (Selangor, Kelantan, Pahang, Melacca). Several schools in Malaysia were not included either because they either declined to participate (n=1) or located in the same area where other schools were included (n=3) in addition to reasons related to budget limitations. A total of 382 undergraduate students participated, and this large cohort (compared to other survey studies on undergraduate students) ensured that results are representative of the overall final year undergraduate dental student population in Malaysia. Notably, this study included only final year undergraduate dental students exposed to both pre-clinical endodontic courses and root canal treatment procedures in different tooth types. It was impossible for one individual lecturer to present at all schools because of time and work constraints, so two calibrated presenters were selected to undertake the presentations. The use of two calibrated presenters did not affect the results as shown in Tables 2-6.

When designing the PPT presentation there was a concern whether to include only the eight types of the original Vertucci classification (Vertucci *et al.* 1974) or also include the supplemental configurations introduced later by others (Gulabivala *et al.* 2001, 2002, Ng *et al.* 2001, Sert & Bayirli 2004). Eventually, it was decided to include both the original and supplemental configurations for the following reasons:

a) Considering only the 8 original canal types as the most common root canal configurations found in clinical practice (suitable for teaching at undergraduate level) is inappropriate because

dental students do not or rarely deal with canal configurations types VI (2-1-2) and VII (1-2-1-2). In other words, even the original eight categories are not all common.

b) Owing to the growing body of knowledge on root and canal morphology, it is essential to equip students with knowledge of both common and less common canal configurations (other than the 8 canal configuration types),

c) Based on current practice and teaching, the prevalence of some canals such as the middle mesial canals in mandibular first molars has become more evident (reaching up to 10% of molar cases of final year undergraduate students in the UM with guidance from the supervisor – unpublished data); such cases may include supplemental canal configuration types such as Vertucci types XV (3-2), XVIII (3-1) and others.

d) Considering only the 8 configuration types compared to the new system would result in many root canal configuration types being considered as “non-classifiable”, which is inappropriate.

Approximately 90% or more of students believed that the new system for classifying root and canal morphology was more accurate and more practical compared to the Vertucci classification and its supplemental configurations ( $P < 0.001$ ). Except for one school (IMU), the results revealed no significant difference between the schools that participated in the survey. Notably, the trend in IMU was the same as other schools (Table 2, 3), in which the majority of students believed that the new system is more accurate (73.3%), and more practical (80%) than the Vertucci classification. More than 95% of students believed that the new system aided their understanding of root and canal morphology, and they would recommend its inclusion in preclinical and clinical courses. Together with the comments provided by the students,

undergraduate students were able to understand and digest the new system in a short time, and were able to provide constructive feedback in the comments section, however, their understanding needs to be investigated further through calibration sessions and by examining their ability to provide consistent reporting on different tooth types with various root and canal anatomical variations. In addition, their understanding should be evaluated on specific aspects of canal systems such as the “common canal” which has been highlighted as a potential point of confusion for some students during the present study. These results should not undermine the value of previous classification systems, and students still have to be aware of their advantages and limitations.

Students raised questions relating to levels of root canals merging and diverging, accessory canals, and other anomalies such as root fusion and C-shaped canals, particularly whether such anatomical variations are or could be included in the new system. This constructive feedback is probably attributed to the fact that the new classification is an “open system”, which may have focused students’ thoughts on other anatomical variations. Even though these anatomical landmarks have been addressed recently (Ahmed *et al.* 2018, Ahmed & Dummer 2018b), these were not included in the current survey, which focused on root and canal morphology. However, such reflections demonstrate the ability of students to apply factual knowledge to understand, analyse, evaluate and even create or add to the original product/system (Krathwohl 2002). Indeed, this also can be a direction for future research, in addition to other anatomical landmarks such as accessory canals which have important clinical implications at undergraduate and postgraduation level. It is worth mentioning that, in a preliminary investigation, this survey was also undertaken on postgraduate dental students ( $n = 21$ ) in two

universities (UM and USM); results were similar to undergraduates in which more than 95% students (n = 20) believe that the new system is more accurate and practical compared to Vertucci classification. All postgraduate students believe that the new system helps their understanding for the root and canal morphology, and they recommend its application in preclinical courses and clinical practice. The response of general dental practitioners, specialists, researchers and lecturers, who are familiar with the Vertucci classification and its supplemental configurations, is also a potential for future research.

## **Conclusions**

Undergraduate dental students in Malaysia believe that the new system for classifying the root and canal morphology is more accurate and practical compared to Vertucci classification. The new system has the potential to be included in the Endodontic curriculum related to the root and canal morphology.

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### **Legends to tables:**

Table 1: Distribution of students' feedback for "question 1" between schools – "compared to Vertucci classification, the new system for classifying root and root canal morphology is".

Table 2: Distribution of students' feedback for "question 2" between schools – "Compared to Vertucci classification, the new system for classifying root and root canal morphology is"



Table 3: Distribution of students' feedback for "question 3" between schools – "the new system for classifying root and root canal morphology helps my understanding to the root and root canal morphology more compared to Vertucci classification".

Table 4: Distribution of students' feedback for "question 4" between schools – "Do you recommend the application of the new system for classifying root and root canal morphology in teaching in your curriculum?".

Table 5: Distribution of students' feedback for "question 5" between schools – "Do you recommend the application of the new system for classifying root and root canal morphology in preclinical courses and clinical practice?".

Table 6: Additional comments and concerns raised by the students.

### **Legends to Figures:**

Figure 1: Schools participated in the survey study and attendance of final undergraduate dental students (Average response rate = 85.5%). [University of Malaya (UM – 56 students), University Sains Malaysia (USM – 44 students), Universiti Teknologi MARA (UiTM – 76 students), University Science Islamic Malaya (USIM – 34 students), MAHSA – 76 students, International Medical University (IMU – 43 students), International Islamic University Malaya (IIUM – 47 students), Melaka-Manipal Medical College (MMMC – 73 students)].

Figure 2: Distribution of students (percentage) who selected answer "A" in the questionnaire following the presentation undertaken by different presenters. Except for question 1, no significant difference was detected between both presenters (Exact test).

### **Supplementary PPT**

Supplementary material 1: The PPT used in this survey study.

Supplementary material 2: The questionnaire used in this survey study.